3. Account of a peculiar Structure found in the Vagmarus Islandicus. By Dr John Reid. Communicated by Professor Goodsir.

4. Notes to a Paper on the Motive Power of Heat. By Professor William Thomson.

(1.) *On the Values of μ derived from Observations on the Vapours of various Liquids.*

An important test of the truth of the axiom on which Carnot's Theory is founded, will be afforded by comparing the values of μ deduced from observations on various liquids. I am informed by Mons. Regnault, that, by the end of this year, data as complete as those which we at present possess for water, will be supplied for five or six different liquids, from certain investigations with which he is now occupied. Carnot gives values of μ for the temperatures of the boiling of sulphuric ether, alcohol, water, and essence of turpentine, derived from various observations upon those liquids. The comparison of these with the values of μ, deduced from Regnault's continuous series of observations on water, are exhibited in the following table :—

Names of the Liquids.	Boiling-points.	Carnot's deduced values of μ.	Values of μ deduced from Regnault's Experiments on Water.	Differences.
		Ft. lbs.	Ft. lbs.	
Sulphuric Ether,	35·5	4·48	4·51	·03
Alcohol, . .	78·8	3·96	4·03	·07
Water, . .	100	3·66	3·84	·18
Essence of Turpentine, .	156·8	3·53	3·45	−·08

The coincidences of the results obtained by such very different experiments are very striking. The differences certainly lie within the limits of the errors of observation ; for it happens that the difference of the two results deduced by the different experimenters, from water at the boiling-point, is greater than any of the other differences. It is very remarkable that the feature of the gradual decrease of μ with the temperature should be so clearly brought out by observations performed on different liquids, at different temperatures.

(2.) *On the Heat developed by the Compression of Air.*

Carnot demonstrates the following proposition :—

Equal volumes of all elastic fluids, when compressed to equal smaller volumes, disengage equal quantities of heat.

This very remarkable proposition, given as a theorem by Carnot, was enunciated as a probable experimental law by Dulong ; and it therefore affords a very powerful confirmation of Carnot's fundamental principle.

Mr Joule of Manchester has made some important experiments on this subject. The view which he takes of a thermal "equivalent" for motive power is at variance with Carnot's theory, but his experimental results agree with its indications in a very satisfactory manner. In endeavouring to effect a comparison, I found that the following propositions are a consequence of Carnot's Theory.

1. *In compressing a gas of which the temperature is kept invariable, the amount of work spent is exactly proportional to the quantity of heat developed.*

2. *The amount of work necessary to produce a unit of heat in this manner is the same, whatever be the gas operated on, but depends upon the temperature, being determined by the expression*

$$\frac{\mu\,(1+\mathrm{E}\,t)}{\mathrm{E}}.$$

(3.) *On the Specific Heats of Gases.*

Carnot proves, as a theorem, that *the excess of the specific heat* under a constant pressure above the specific heat at a constant volume is the same for all gases at the same temperature and pressure.*

This result agrees well with the experimental results obtained by Dulong.

Carnot's theory affords the following determinate expression for the difference alluded to in the enunciation :

$$\frac{\mathrm{E}^2\,p}{\mu\,(1+\mathrm{E}\,t)^2}$$

* *i.e.* The "capacity for heat" of a unit of volume.

(4.) *Comparison of the Relative Advantages of the Steam-Engine and Air-Engine.*

In the steam-engine, with the expansive principle pushed to the utmost, as Carnot points out, the *effective range of temperature*, or the *fall* utilised, is from the temperature of the boiler to that of the condenser. The superior limit of temperature is restricted by the circumstance, that the pressure of saturated steam is enormously great for high temperatures; so that in practice, the temperature in the boiler is not in any ordinary engines so high as 150° per cent., but is in general very much below this limit. Carnot points out, that in this respect, the air-engine has a vast advantage over the steam-engine; as there is no limit to the temperature in the hot part, except such as the preservation of the materials requires; and, therefore, in it an enormously greater portion of the whole fall, from the temperature of the coals to that of the atmosphere, may be made use of. In other respects, we have no reason *a priori* for giving a preference to one kind of engine above the other. We cannot, however, feel confident that any air-engine has yet been constructed, which is capable of economising the fall actually used, as well as is done by steam-engines, with their comparatively limited range of temperature, or even that the duty for fuel consumed has in any actual air-engine exceeded or even come up to the duty performed by the best steam-engines.

(5.) *On the Economy of Actual Steam-Engines.*

The following table affords a synoptic view of the performances and theoretical duties, in various actual cases.*

When heat is transmitted from a body at 140°,† through an engine, to a body at 30°, the work due to each unit of heat is 439 foot-pounds. This is the "theoretical duty" referred to in the last column in the table.

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* I am indebted to the kindness of Professor Gordon, of Glasgow, for the experimental data.

† Pressure $3\frac{1}{2}$ atmospheres; 37 lb. on the square inch of the safety-valve.

Table A.—*Various Engines in which the Boiler is at* 140°, *and the Condenser at* 30°.

Cases.	Work produced for each lb. of coal consumed.	Work produced for each lb. of water evaporated.	Work produced for each unit of heat transmitted.	Per-centage of theoretical duty.
	Ft.-lbs.	Ft.-lbs.	Ft.-lbs.	
(1.) Fowey Consols Experiment, reported in 1845,	1,488,000	175,000	283	$64\frac{1}{2}$
(2.) Taylor's Engine at the United Mines, working in 1840,	1,167,000	137,300	222	$50\frac{1}{2}$
(3.) French Engines, according to contract,	* * * *	98,427	159	36
(4.) English Engines according to contract,	565,700	66,550	108	$24\frac{1}{2}$
(5.) Average actual performance of Cornish Engines,	631,000	74,240	120	$27\frac{1}{3}$
(6.) Common Engines, consuming 12 lb. of coal per hour, per horse-power.	165,000	19,410	31·4	$7\frac{1}{6}$
(7.) Improved Engines, with expansion cylinders; using an equivalent to 4 lb. of best coal per horse-power, per hour.	495,000	58,240	94·3	$21\frac{1}{2}$

5. Note regarding an Experiment suggested by Professor Robison. By Professor J. D. Forbes.

In his memoir of Dr Chalmers, lately read to this Society, Mr Ramsay has referred to an experiment which Dr Chalmers was anxious to have performed on the tide-wave in the Bay of Fundy. The object was to determine the earth's density by the attraction of the tide-wave on a plummet or spirit-level, on the same principle as